velocity, as the second point when projected down will nearly coincide with the first; but it is necessary to swing this point up to obtain the change in direction of the wind.

2. The angle ϕ will not always be added to the previous azimuth. A set of four rules is furnished with the "Calculator" which are to be applied in determining the wind direction.

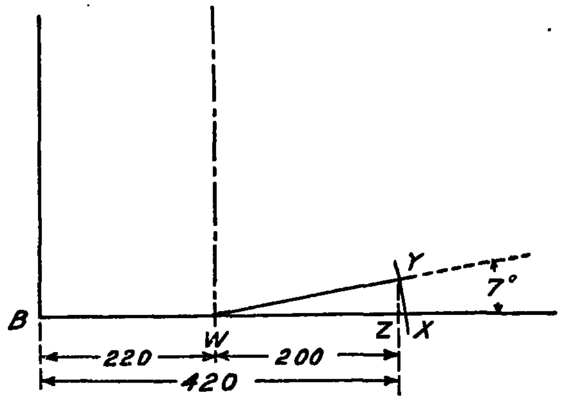

Fig. 4.

THE "TWITCHELL" METHOD.

This method applies a mechanical device to the "Calculator" which makes the manipulation much easier, simpler, and quicker to follow through. A graduated celluloid scale is pivoted at the origin of the calculator as shown in figure 3.

The point O is pivoted at the origin of the "Calculator." the scale OBX is graduated in the proper relation to the scale of the calculator, so that it reads directly in m. p. s.

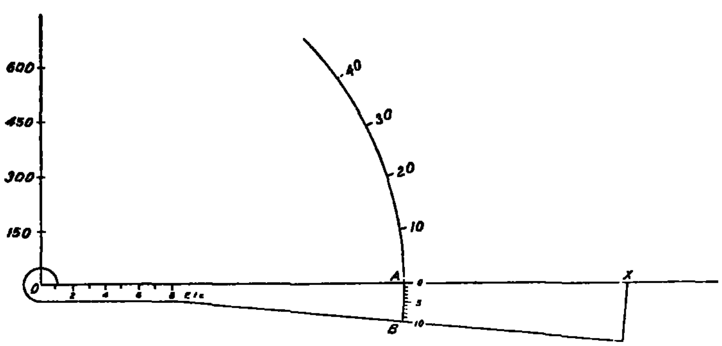

Fig. 5—The "Twitchell" method.

At a radius of about 20 cm. from O there is a modified vernier scale, AB. The arc AB is made to equal exactly 10° of a circle of that particular radius. On the calculator it is necessary to have only 10° divisions as the scale allows for any fraction between these divisions.

The use of the rule is as follows:

We will assume the same data as before.

1. Read up the left-hand distance scale to 150 meters. Set the lever so that the ruled edge lies on the 31.8° line. Read over on the 150 meter line until it intersects this edge. Follow this point vertically downward to the scale below. Move the lever down so that the ruled edge coincides with the bottom of the chart and read the velocity from the lever in m. p. s.

2. Read up the left-hand distance scale to 300 meters. Set the lever to read the vertical angle 35.6°. Find the intersection with the 300-meter line and project the point vertically downward to the bottom scale. By means of the lever establish the point Y as in figure 3. By means of an auxiliary scale measure the horizontal and vertical distances of this point from the point W, figure 3, and lay them off from the origin. They determine a point which in turn determines ϕ. Let the lever measure this angle (7.0°). Add this to the previous azimuth and obtain the wind direction $(90.5+7.0)=97.5°$. The distance WZ gives the wind velocity.

The steps are the same for succeeding operations.

The same rules for finding wind direction apply as with the "Calculator."

BRITISH PILOT-BALLOON METHODS: THE SHOEBURYNESS SYSTEM.

[Reprinted from Meteorological Office Circular 30, Nov. 26, 1918, pp. 1-2.]

The following is a description of the double-theodolite method in use at Shoeburyness: The method is a combination of graphical and slide-rule methods. On a large drawing board there are fixed two of the radial charts supplied by the Meteorological Office, joined so as to have lines radiating to the left as well as to the right. The common center of these charts represents the home station. A paper protractor (obtained by cutting up a radial chart) is arranged so that its center is at a distance from the center of the radial charts equal to the length of the base between the theodolite stations on a scale of 2 cm. to 600 feet; the bearing of the center of the protractor is the bearing of the distant, from the home, station. The whole is covered with a sheet of tracing paper on which the path of the balloon is plotted. The tracing paper is renewed when necessary, but the radial charts seldom require renewal. Two Chesterman steel tapes are pivoted one at the center of the radial chart and the other at the center of the protractor. The home theodolite is set with azimuth N.=180° and the distant theodolite with zero—bearing of the home station. The steel tapes are set according to the simultaneous readings of the azimuth of the balloon, and their intersection on the plotting tables gives the projection of the balloon. Successive positions at intervals of one minute are plotted in this way. The wind speed is obtained directly in feet per second by measuring the distances between successive points. As the scale is 2 cm. to 600 feet the speed in feet per second is measured on the scale of 2 cm. to 10 f./s. The wind-direction is obtained by setting a rolling parallel ruler along the line joining two successive points; the ruler is then rolled until it coincides with one of the lines of the radial charts. This gives the wind-direction directly. The distances from the intersections on the charts to the origins are read off on the steel tapes, 2 cm. being taken as the unit. These give HcotE/600 for each station where H is the height in feet above the station from which the elevation of the balloon is E. From this the height above each station is computed by slide-rule. A pilot balloon slide-rule is used: 1 on the inner slide is set against 6 on the main slide. The tangent cursor is set to the complement of the angle of elevation and the inner slide is then set so that the horizontal distance of the balloon from either station, as measured on the plotting board, falls under the cursor. Height in feet is then read against the end of the sine-scale.

The ends of the base and the office where the computing is done are connected by telephone. The telephone installation is arranged so that any observer who is using the telephone can speak to and hear either of the other two. This is the case whichever base is being used. Five observers are required; they are allocated as follows:

Two at the station from which the balloon is being released (the home station).

One at the other station (the distant station).

Two in the office computing.

At the home station, one of the observers follows the balloon. The other, who is at the telephone, gives the needful time signals and transmits the observations of his own station to the office: the observer at the distant station transmits his own observations on hearing the time signals given by the home observer. To prevent any confusion, the routine adopted is for the distant observer to send his readings through first, and for the home station to send theirs immediately afterwards.

In the office there are two computers. The one who is wearing the telephone receives the observations and notes them on the special form, at the same time giving them verbally to the second computer, who plots them on his radial chart and reads off the values HcotE/600, wind speed and direction. He gives these to the first computer, who enters them on the form and, by means of the slide rule, calculates the height of the balloon above each station. The necessary computing is done before the reading for the next minute becomes due. Thus the whole work can be done during the balloon ascent, and results are obtained just as rapidly as with single-theodolite observations.

Telephone connections are available at each angle of a triangle, which is nearly equilateral, with sides which are about 4,000 feet long. The base used may be any one of the sides of this triangle, and the particular side to be used is that which will be most nearly at right angles to the path of the balloon.

FREE-BALLOON FLIGHT IN THE NORTHEAST QUADRANT OF AN INTENSE CYCLONE.

By Lieut. C. LEROY MEISINGER, Signal Corps Meteorological Service.

[Dated: Fort Omaha, Nebr., Mar. 26, 1919.]

At 3:37 on the morning of March 14, 1919, the writer participated in a free-balloon flight from Fort Omaha, Nebr. The balloon had a capacity of 35,000 cubic feet and carried a party of five, piloted by Lieut. Ralph A. Reynolds. Owing to a somewhat gusty east wind, which seemed to bear the balloon down upon the ground, the oscillations of the bag were so severe as to cause the basket to crash into the ground on the getaway, rendering the barograph useless. Nevertheless, the whole experience was one of beauty—the full moon above the fog billows, the sunrise, and finally the landing in the fog. At 9:10 a landing was effected in a field about 8 miles southeast of Geddes, S. Dak.—an air-line distance of 322 kilometers from the starting point.

Table 1 is a summary of the flight:

TABLE 1.—*Record of free-balloon voyage, Mar. 14, 1919.*

Time.	Altitude (altimeter set 0 at Fort Omaha).	Probable direction of travel.	Temperature.[1]	Remarks.
A. M.	*Feet.*		° *F.*	
3:37	[2]	W.	30	
3:47	1,750	W.	30	Above clouds.
3:57	1,750	N.	30	Do.
4:07	1,800	N.	30	Do.
4:22	1,850	N.	30	In clouds.
4:37	1,850	NW.	26	Do.
4:52	1,850	NW.	26	Do.
5:07	1,850	NW.	26	Do.
5:22	1,900	NW.	26	Do.
5:37	1,950	NW.	26	Do.
5:52	1,800	W.	22	Do.
6:07	1,825	W.	22	Do.
6:22	1,650	W.	21	Trail rope touched ground at about 6:30
6:37	[3] 700	W.	28	In clouds.
6:52	850	W.	30	Above clouds.
7:07	700	W.	32	Do.
7:22	900	NW.	32	Above clouds; first appearance of sun.
7:37	900	NW.	[4] 38	Above clouds.
7:52	1,400	NW.	38	Do.
8:07	1,750	NW.	38	Do.
8:22	1,750	NW.	38	In clouds.
8:37	1,600	NW.	38	Do.
8:52	1,000	NW.	26	Do.
9:10 [5]	....	....	....	

[1] Thermometer of cheap commercial make.
[2] Left ground.
[3] Altimeter reset by about 1,100 feet after trail rope touched ground.
[4] Temperature uncertain, as thermometer was not shielded from sun.
[5] Landed 8 miles southeast of Geddes, S. Dak.

First, let us consider the pressure distribution on the morning in question, namely, March 14. (See fig. 1.) There was an area of high pressure over eastern Canada and a low-pressure area centered in northern Colorado. The gradient was quite steep, due to a pressure difference of over 50 millibars (observed difference 1.68 in.) between the two centers. The isobars of the Middle West were almost parallel in a northwest-southeast direction. Because of this steepness of gradient, high winds in this region were to be expected. During the day the center of low pressure moved in a northeasterly direction, and in northern Nebraska there were ver yhigh winds, accompanied in the afternoon by terrific hailstorms and, in several places, by small tornadoes. This leaves little doubt as to the eddying and somewhat turbulent state of the atmosphere in this vicinity.

On the morning of the departure the wind was easterly on the surface and quite gusty. The sky was overcast

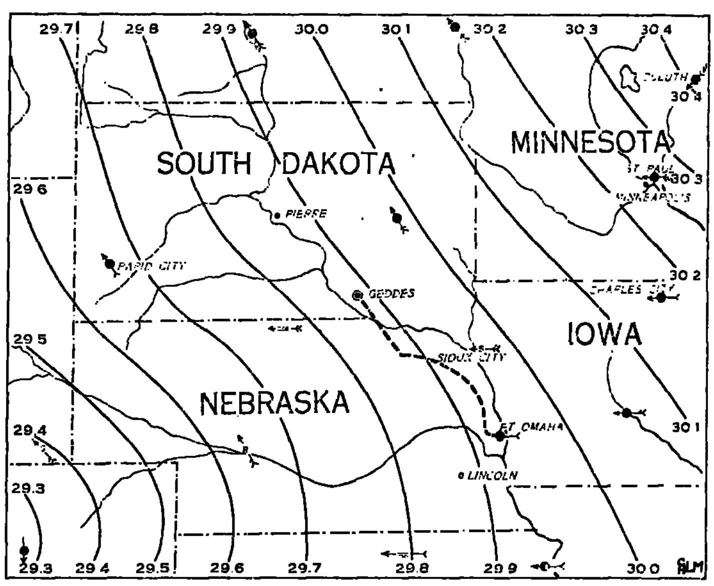

FIG. 1.—Weather map, 7 a. m., 90th meridian time. Mar. 14, 1919; and probable route taken by the balloon.

with a very low stratus sheet, the base of which was not over 300 feet above the ground. As nearly as could be judged, these clouds were moving about 9 meters per second from the east. The balloon, of course, left the ground moving west and maintained this direction while passing into the clouds. Quickly passing through the cloud layer, for it was not very thick, we encountered